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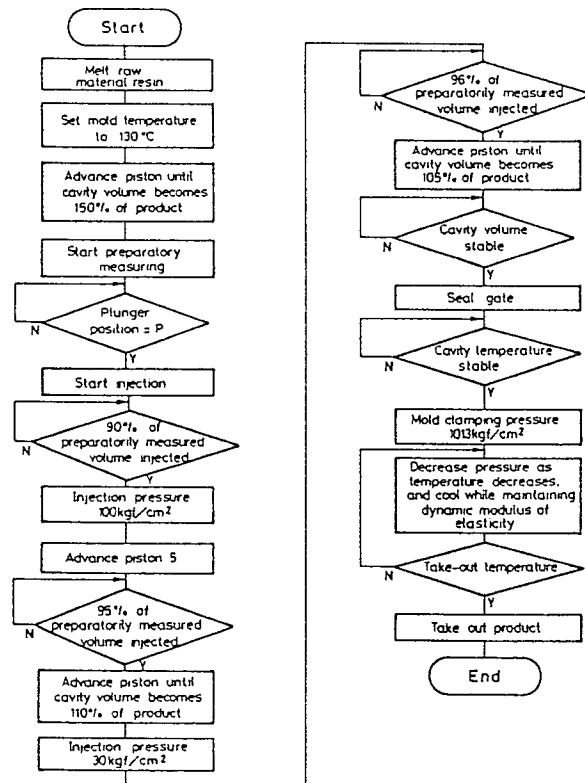
(54) **INJECTING MOLDING METHOD INVOLVING PRESSING.**

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(57) In an injection molding method involving pressing for producing a molded article by injecting a plasticized and measured thermoplastic resin into cavities through a sprue - runner - gate and cooling it with a mold clamping force applied, the present invention provides a method for preventing the occurrence of weld marks, non-uniformity of injected resin quantities among a plurality of cavities, photoelastic strain, flow marks, and the like. A cavity formed inside the mold is in advance expanded to a volume sufficient to prevent a branch flow of in-flowing resin and is kept at a temperature sufficient for the resin to keep a fluidization state. The thermoplastic resin which is heated and is under a molten state is preparatorily measured and injected into this

expanded cavity in quantity greater than necessary for obtaining a molded article. Before the full quantity of this thermoplastic resin measured in advance is injected into the cavity, the cavity is diminished. At the point of time when the cavity is diminished to a sum of the volume of the molded article and the mold shrinkage quantity of the thermoplastic resin due to cooling, this diminishing operation is controlled in such a manner as not to leave any uncharged portions inside the cavity which would cause flow marks. At the time of its diminution, the injection pressure is lowered to a pressure at which the backflow of the thermoplastic resin, which might have been over-changed into the cavity, from the cavity due to the diminution of the cavity is not

prevented and the resin can be injected to the uncharged portions where the resin might remain inside the cavity. The sprue is cut off when the behaviour of the resin inside the cavity goes stable, and the resin injected into the cavity is cooled and hardened under pressure to a withdrawing temperature.

FIG.3



DESCRIPTION

INJECTION MOLDING METHOD WITH STAMPING COMPRESSION

TECHNICAL FIELD

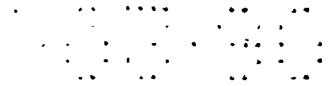
This invention relates to an injection molding method with stamping compression, and more particularly to an injection molding method with stamping compression most suitable for molding articles which require high molding precision and compositional homogeneity such as optical lenses.

BACKGROUND ART

Examples of typical known art for obtaining molded articles from thermoplastic resin will be described below.

First, the cavity is expanded preparatorily to prevent the generation of weld mark on the surface of molded articles, and thermoplastic resin in molten state which is measured previously to a quantity required for obtaining the molded articles is injected to the expanded cavity.

After this injection operation is completed and the gate is sealed, the thermoplastic resin injected to the cavity is cooled to a take-out temperature with mold clamping force applied, and the molded article is now obtained.



However, the method in prior art involves problems as follows.

In the case when one mold has two or more cavities, to completely equalize the easiness of resin flow into the cavities is very difficult. Accordingly, much resin is injected into a cavity into which resin flow is easier than the other, and unbalance occurs in the quantity of resin filling the cavities.

In addition, since the cavity is expanded to prevent weld mark, when injection of measured resin is completed, resin flow stops leaving a large unfilled portion in the cavity. As a result, flow marks tend to occur along the boundary line of the filled portion and unfilled portion.

Furthermore, photoelastic distortion occurs at a point where the flow mark generates.

Another example of prior art which is known is as follows.

First, the cavity is preparatorily expanded to prevent the generation of a weld mark on the surface of a molded article, and thermoplastic resin in molten state is injected to fill the cavity with the thermoplastic resin completely.

Then, with the gate no sealed, the cavity is reduced in volume and overcharged thermoplastic resin is



caused to make backflow from the cavity. When the cavity is reduced to a desired volume, the gate is sealed, and the thermoplastic resin is cooled and hardened under pressure.

However, the above-mentioned example of prior art has a problem, that is, due to a large quantity of backflow of the thermoplastic resin, photoelastic distortion tends to occur around the inlet of the cavity.

In addition, both the former and latter examples have the following problems.

Though when the thermoplastic resin is cooled from molten state of a high temperature and hardened, its dynamic modulus of elasticity varies and the resin becomes hard, the dynamic modulus of elasticity does not vary linearly throughout the temperature range during cooling, but the dynamic modulus of elasticity abruptly varies at a certain temperature (glass transition point, T_g).

Because of this characteristic, if there occurs temperature difference from part to part when the resin temperature goes through the glass transition point while being cooled, there occurs a portion where the resin is in the solidified state and a portion where the resin is in the molten state. In the conventional molding method, no special consideration is given to the temperature difference from part to part in the resin, and the process is proceeded to the compression process. As a result, the portion in the



solidified state tends to cause plastic deformation and the internal composition tends to become heterogeneous.

The object of the present invention is to solve above-mentioned problems.

In particular, the present invention provides an injection molding method with stamping compression characterized by free of unbalance in the quantity of resin to be filled in a plurality of cavities occurring due to preparatory expansion of cavity for preventing weld mark at the time of injection.

In addition, the present invention provides an injection molding method with stamping compression free of generation of flow mark or photoelastic distortion due to stopping of resin flow with a large unfilled portion remaining in the cavity when the injection operation completed.

In addition, the present invention provides an injection molding method with stamping compression free of generating photoelastic distortion resulting from the backflow of a large quantity of resin from the cavity when the cavity shrinks.

Further, the present invention provides an injection molding method with compression capable of preventing the internal composition of molded articles from becoming heterogeneous and preventing plastic deformation of a

portion where the solidification occurs quickly, by preventing presence of a portion of resin in a solidified state and a portion of resin in a molten state together due to temperature difference in the resin when the resin is cooled and passes through the glass transition point to the low temperature side.

DISCLOSURE OF INVENTION

In the injection molding method with stamping compression according to the present invention, the volume of one or more than one cavities formed in the mold is previously expanded to a volume which is more than the sum of the volume of the article to be molded and a volume of molding shrinkage due to cooling of the thermoplastic resin and which is a volume sufficient for preventing divided flow of resin flowing into the cavities, and the temperature is controlled to level required for maintaining the injected resin in a flowing state.

A plurality of cavities may be provided in a single molded apparatus.

The resin to be injected is preparatorily measured by a measuring injection means, e.g., an injection plunger or the like. In this preparatory measuring, molten thermoplastic resin of the quantity more than required for obtaining a desired molded article is measured.

The thermoplastic resin thus measured is injected into one or more cavities formed in a mold. No divided flow occurs in the resin flowing into the cavities and accordingly no weld mark is generated because the cavity is expanded and cavity temperature is maintained at flow temperature of resin or higher.

The cavity begins to shrink before the completion of injection operation of the resin, and the cavity shrinking operation and resin injection speed are controlled so that no unfilled portion which is large enough to generate a flow mark remains in the cavity when the cavity is reduced to a volume equal to the sum of the volume of the article to be molded and a volume of molding shrinkage due to the cooling of the thermoplastic resin.

The injection pressure of the resin is lowered to the retaining pressure which does not obstruct backflow to the cavity of the resin likely to be overcharged to the cavity due to the cavity contraction and which allows the injection of the resin into any unfilled portion likely to remain in the cavity when the cavity is contracted at least to a volume equal to the sum of the volume of the molded article and a volume of molding shrinkage due to the cooling of the thermoplastic resin.

Accordingly, at this point, the internal pressure of the cavity in which the resin is slightly overcharged is

higher than the retaining pressure, and therefore slightly overcharged resin backflows due to the pressure difference with the retaining pressure.

On the other hand, to the cavity having a slightly unfilled portion, the resin keeps flowing by the resin retaining pressure and backflow pressure from other cavity.

When the volume of the cavity is contracted to a value equal to the sum of the volume of the molded article and a volume of molding shrinkage due to the cooling of the thermoplastic resin in the cavity and behavior of the resin in the cavity becomes stable, the sprue is sealed, and all cavities are filled with the resin of the quantity determined by taking into account the molding shrinkage due to cooling.

As already mentioned, thermoplastic resin has a character that its dynamic modulus of elasticity increases with cooling down and the resin is hardened. Particularly, when it goes through the glass transition point, its dynamic modulus of elasticity abruptly varies. In addition to such character, resin has a character that its dynamic modulus of elasticity increases by increasing the pressure even if temperature is the same, and its glass transition point shifts to the higher temperature side.

This means that thermoplastic resin is easily hardened at a high temperature (temperature, e.g., 130 °C,

at which acrylic resin is in a flow state under normal pressure) correspondingly when a high pressure is applied.

The present invention utilizes such character of thermoplastic resin.

When the sprue is sealed, temperature in the cavity is maintained to a temperature at which the resin keeps the flow state under normal pressure, and the resin in the cavity is in such a condition that pressure can be transmitted uniformly to the entire portion.

If mold clamping force is applied to the cavity in this condition, the resin in the cavity increase its dynamic modulus of elasticity without accompanying temperature decrease.

According to the present invention, by applying a pressure which can provide dynamic modulus of elasticity of the resin at normal temperature and normal pressure to the resin in the cavity after the sprue is sealed, the resin can be hardened without temperature drop or with a slight temperature drop.

The resin whose dynamic modulus of elasticity is increased by applying pressure is cooled in the cavity.

As described above, thermoplastic resin has a characteristic that its dynamic modulus of elasticity increases when cooled. Accordingly, by decreasing compression force as the resin is cooled, the resin in the

cavity is cooled down to a take-out temperature while maintaining the dynamic modulus of elasticity of the resin in the cavity to the dynamic modulus of elasticity at the time of normal temperature and normal pressure.

When the resin in the cavity is cooled to the take-out temperature, the resin forms a complete molded article. Now, the molded article is taken out by opening the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of a injection molding apparatus with direct pressure type stamping compression to be used in the present invention cut away along the center line of a mold clamping cylinder;

Fig. 2 is a sectional view of an injection molding apparatus with stamping compression shown in Fig. 1 cut away along the center line of tie bar;

Fig. 3 is a flowchart showing the operation of the present invention;

Fig. 4 is a view showing the appearance of the cavities when 90% of preparatorily measured resin is injected;

Fig. 5 is a view showing the appearance of the cavities when 95% of the preparatorily measured resin is injected;

Fig. 6 is a view showing the appearance of the cavities when 96% or more of the preparatorily measured resin is injected; and

Fig. 7 is a view showing the appearance of the cavities after a gate is sealed.

BEST MODE FOR CARRYING OUT THE INVENTION

Figs. 1 and 2 show an example of injection molding apparatus with stamping compression to be used for molding in accordance with the method of the present invention.

On the upper end of the bars 2 planted at four corners of a fixed plate 1, a cylinder fixing plate 4, on which a mold clamp cylinder 3 is attached, is unmovably installed.

To the end of a piston 5 of the mold clamp cylinder 3, a movable plate 6 is fixed. This movable plate 6 ascends and descends along the tie bars 2 as the piston 5 advances and retracts.

On the top face of the fixed plate 1, a lower mold plate 7 is fixed, and in the lower mold plate 7 lower mold inserts 8 and 9 are contained.

On the bottom face of the movable plate 6, an upper mold suspension member 10 is fixed.

An upper mold plate 11 being in contact with the lower mold plate 7 is suspended from the upper mold

suspension member 10 by bolts 12 and 13. A compression spring 14 provided around the bolt 12 and a compression spring 15 provided around the bolt 13 produce a departing force between the upper mold suspension member 10 and upper mold plate 11.

Upper mold inserts 16 and 17 are provided in the upper mold plate 11 at points just above the lower mold inserts 8 and 9 respectively in a manner permitting ascending and descending.

Head flanges 16a and 17a of the upper mold inserts 16 and 17 exist in an internal space 10a of the upper mold suspension member 10. The head flanges 16a and 17a are supported in the internal space 10a of the upper mold suspension member 10 by compression springs 18 and 19 respectively, and the top end faces of the head flanges 16a and 17a are in contact with the bottom face of the movable plate 6.

Inside the compression springs 18 and 19, return pins 20 and 21 are provided respectively to guide the compression springs 18 and 19.

As detailed in Fig. 2, an auxiliary cylinder 22 is screwed to the bottom end of each tie bar 2, and the end of a piston 23 of the auxiliary cylinder 22 penetrates a lower flange 24 and is screwed to a bottomed cylindrical case 25.

On the top end face of the case 25, a pin 26 is

installed vertically. This pin 26 passes through a through hole formed in the fixed plate 1, and can ascend and descend.

A vertically long spacer ring 27 is disposed around the tie bar 2, and the bottom surface of the spacer ring 27 is supported by the pin 26.

In an injection cylinder 28 for measuring and injecting molten resin, a plunger 29 is provided. The plunger 29 advances and retracts in the injection cylinder 28 by a driving mechanism, e.g., a hydraulic cylinder (not shown).

A nozzle 28a of the injection cylinder 28 is depressed to a sprue 30 of the lower mold plate 7 by cylinders (not shown), and the sprue 30 is connected to a gate 32a of a cavity 32 and a gate 33a of a cavity 33 through a runner 31 formed on junction surfaces of the lower mold plate 7 and the upper mold plate 11.

A fixed member 34a fixed to the fixed plate 1 and a moving member 34b fixed to the movable plate 6 together make a position sensor 34 for detecting the position of the movable plate 6.

More particularly, the fixed member 34a and the moving member 34b make, for example, a potentiometer, and as the movable plate 6 ascends or descends the relative distance of the moving member 34b from the fixed member 34a

varies. Since the position of the fixed member 34a is fixed, the output of the position sensor 34 primarily shows the position of the movable plate 6.

As the movable plate 6 ascends or descends, the upper die inserts 16 and 17 ascend or descend. Since the volumes of the cavities 32 and 33 are determined according to the ascending and descending positions of the upper mold inserts 16 and 17, the output of the position sensor 34 eventually indicates the volumes of the cavities 32 and 33.

The reference number 35 denotes a position sensor for indicating the position of the plunger 29. Though the position sensor 35 primarily indicates the position of the plunger 29, the difference between the present position of the plunger during injection and the initial position P corresponds to the quantity of injected resin on the premise that the plunger initial position P at the time of completion of the preparatory measurement is fixed. Accordingly, the quantity of injected resin can be known from the output of the position sensor 35.

Now, referencing the above information the operation to form a minus lens from acrylic resin according to the method of the present invention will be described.

Fig. 3 (flowchart) will facilitate understanding of the present invention.

First, acrylic resin (raw material) is heated and

is in a molten state.

In addition, temperature in the cavities 32 and 33 is adjusted to 130 °C at which acrylic resin can maintain flow condition under normal pressure.

Further, a hydraulic circuit connected to a port 22a of an auxiliary cylinder 22 is not closed, and the piston 23 is ready to be ascended or descended by an external force. In other words, the auxiliary cylinder 22 is in the condition that the lowering of the movable plate 6 is not interfered by this cylinder.

When oil is supplied to a port 3a of the mold clamp cylinder 3 after the initial setting, the piston 5 advances and lower the movable plate 6.

As the movable plate 6 descends, the upper mold suspension member 10 also descends, and the upper mold plate 11 also descends via the bolts 12 and 13. The upper mold plate 11 and the lower mold plate 7 are joined by the departing force of the compression springs 14 and 15 created between the upper mold suspension member 10 and the upper mold plate 11.

In addition, since the bottom face of the movable plate 6 and the upper flanges 16a and 17a of the upper mold inserts 16 and 17 are in contact with each other, when the movable plate 6 descends, the upper mold inserts 16 and 17 also descend.

As the upper mold inserts 16 and 17 descend, volumes of the cavities 32 and 33 decrease, and eventually the volumes of the cavities 32 and 33 are reduced to a value equal to 150% of the volume of the lens to be molded. The value "150%" is a volume required for not generating divided flow for acrylic resin flowing into the cavities 32 and 33, and varies according to the shapes and fluidity of the resin. It is also required that the volumes of the cavities 32 and 33 can store acrylic resin of quantity greater than that required for molding the lens.

Volumes of cavities 32 and 33 varying as the movable plate 6 descends can be known by the position sensor 34. When the output of the position sensor 34 indicates the reduction of volumes of the cavities 32 and 33 to 150% of volume of the lens to be molded at normal temperature and normal pressure, the auxiliary cylinder 22 operates to fix the volumes of the cavities 32 and 33 in that position.

More particularly, the hydraulic circuit connected to the port 22a of the auxiliary cylinder 22 is shut off by a shut-off valve or the like, and as a result the position of the piston 23 is fixed. Since a pin 26 and a spacer ring 27 are mounted on the top of the cap 25 connected to this piston 23, fixing the position of the piston 23 interferes with lowering of the spacer ring 27.

As a result, since the spacer ring 27 supports the

movable plate 6 in that position, the volumes of the cavities 32 and 33 are fixed. As this time, the propelling force of the mold clamp cylinder 3 is also controlled so as to fix the volumes of the cavities 32 and 33.

In this manner, when the volumes of the cavities 32 and 33 are fixed to a volume equal to 150% of the volume of the lens to be molded at normal temperature and normal pressure, preparatory measuring operation is performed by the injection cylinder 28.

First, when resin is loaded to the injection cylinder 28 from a screw mechanism or other mechanism (not shown), the plunger 29 retracts within the injection cylinder 28. The amount of retraction of the plunger 29 corresponds to the amount of resin flowing into the injection cylinder 28, and the amount of retraction of the plunger 29 can be known by the position sensor 35.

When the plunger 29 is retracted to the position P, acrylic resin of quantity more than required for obtaining a molded lens is stored in the injection cylinder 28.

When the output of the position sensor 35 indicates that the plunger 29 has retracted to the position P, the preparatory measuring operation ends, and injection operation starts.

The injection operation of resin is performed by raising the plunger 29.

When the plunger 29 ascends in the injection cylinder 28 by means of a hydraulic cylinder or the like (not shown), acrylic resin stored in the injection cylinder 28 by the preparatory measuring operation starts to flow into the cavities 32 and 33 through the route of nozzle 28a - sprue 30 - runner 31 - gates 32a and 33a.

At this time, since the temperature in the cavities 32 and 33 is set to 130 °C at which acrylic resin (material) is maintained in a flowing state, acrylic resin flowing into the cavities 32 and 33 is kept in a flowing state.

In addition, at this time, the volumes of the cavities 32 and 33 are expanded to a volume equal to 150% of the volume of the lens to be molded at the normal temperature and normal pressure, injected resin flows into the cavities 32 and 33 without being divided. Accordingly, no weld mark is generated. At this time, quantities of resin flowing into the cavities 32 and 33 are not always the same, and more resin flows into the cavity of smaller fluid resistance.

As the injection operation progresses, the output of the position sensor 35 varies, and the quantity of the injected resin can be known by the output of the position sensor 35.

By the way, when the volumes of the cavities 32 and 33 are reduced after total quantity of preparatorily

measured resin (more than required for obtaining a molded article) is injected, a large amount of backflow of resin from the cavities 32 and 33 occurs owing to the mold clamping action and photoelastic distortion occurs around the gates 32a and 33a of the cavities 32 and 33.

According to the present invention, in order to prevent the generation of a large amount of backflow at the time of mold clamping, a large amount of overcharge to the cavities 32 and 33 is prevented by lowering the upper mold inserts 16 and 17 before completion of the injection operation of resin and reducing the volumes of the cavities 32 and 33.

On the other hand, if the volumes of the cavities 32 and 33 are reduced in the early stage of the injection operation, divided flow of resin occurs in the cavities 32 and 33 and a weld line is generated at the junction of the divided flow.

According to the present invention, the reduction operation of the volumes of the cavities 32 and 33 is so timed that it is performed when resin has flowed into the cavities 32 and 33 to the extent that a weld line does not occur even when the volumes of cavities 32 and 33 are reduced.

A proper timing of reducing the volumes of the cavities 32 and 33 varies according to the character of

resin, shape of the cavities 32 and 33, and so on.

For example, in the case of forming a minus lens from acrylic resin, it is desirable to start reduction operation of the cavity volume after the front end of resin flowing into the cavities 32 and 33 passed the position of the optical axis of the lens (i.e., after the front end of flowing resin completely passed the narrowest part of the thicknesses of the cavities 32 and 33). In addition, for determining the reduction start timing of the cavity volume, difference in easiness of flowing between into the cavities 32 and 33 must be taken into account.

In Figs. 4 thru 7, assumption has been made that the cavity 32 (right side) is smaller in fluid resistance than the cavity 33 (left side) and is easier for resin to flow into. The figures of percentage used in these figures denote the ratio of the volumes of the cavities 32 and 33 to the volume of the lens to be molded.

First, Fig. 4 shows the state when the front end of resin 36 flowing into the cavity 33, which has greater fluid resistance and accordingly resin flow into which is harder, passed the optical axis position.

The cavity volume reduction operation is started after the output of the position sensor 35 indicates that the injection operation has progressed to the extent that resin of the quantity equal to 90% of preparatorily measured

resin is injected, provided it has been verified by trial operations that the state in the cavities 32 and 33 is as shown in Fig. 4 when the injection operation progresses to the extent that resin of the quantity equal to 90% of preparatorily measured resin is injected. Injection operation of resin 36 continues while this cavity volume reduction operation is being performed.

For the cavity volume reduction, first the hydraulic circuit of the port 22a of the auxiliary cylinder is opened.

When the hydraulic circuit connected to the port 22a is not closed, the lowering of the spacer ring 27, pin 26, case 25, and piston pin 23, and movable plate 6 is not obstructed. Though the auxiliary cylinder 22 is not mentioned in the following, the hydraulic circuit of the auxiliary cylinder 22 is opened at the time of advance of the mold clamp cylinder 3, and the hydraulic circuit of the auxiliary cylinder is closed at the time of fixing the cavity position.

As the upper mold inserts 16 and 17 are lowered by supplying oil to the port 3a of the mold clamp cylinder 3, the volumes of the cavities 32 and 33 are reduced.

At this time, injection pressure of resin by the plunger 29 is lowered to 100 kgf/cm². The meaning of this injection pressure "100 kgf/cm²" will be described in detail

later.

By the continuous supply of resin from the injection cylinder 28 and reduction of volumes of the cavities 32 and 33, resin 36 having flowed into the cavities flows deeper into the cavities 32 and 33.

The injection operation of resin by the plunger 29 at the injection pressure 100 kgf/cm^2 is preformed together with the volume reduction operation of the cavities 32 and 33 by the mold clamp cylinder 3, and it is controlled so that the volumes of the cavities 32 and 33 are reduced to 110% of the volume of the lens to be molded when 95% of preparatorily measured resin is injected.

The value 110% varies according to the character of resin used and the shape of the cavity, and it is not a fixed value. Now, the meaning of 110% and the meaning of 100 kgf/cm^2 (injection pressure) will be described in detail.

Assume that the volume of the lens to be molded is 100%, retaining pressure to stabilize the quantity of resin flowing between the cavities 32 and 33 is 30 kgf/cm^2 , and molding shrinkage rate of the lens due to cooling from the condition with this retaining pressure applied is 5%, then when entire injection operation is finished and the sprue is sealed by the sprue cutter 37, the volumes of the cavities 32 and 33 need to be 105% of the volume of the lens to be

molded. And, for example, assume that when 95% of preparatorily measured resin (Fig.5) is injected, the cavity 32 is completely filled, then the cavity 32 is in the condition of overcharge by the amount corresponding to the volume equivalent to the difference (5%) of 110% and 105% of difference (70 kgf/cm²) of injection pressure 100 kgf/cm² and retaining pressure 30 kgf/cm².

Accordingly, when the volume of the cavity 32 is reduced to a volume equivalent to 105% of the volume of the lens to be molded (Volume with molding shrinkage due to cooling considered). overcharged resin backflows from the cavity 32. When the amount of backflow exceeds a certain allowable value, photoelastic distortion occurs in the vicinity of the gate 32a of the cavity 32. The value 110% related to a volume and the value 100 kgf/cm² related to pressure determined so that the amount of the backflow occurring when the injection pressure is decreased to retaining pressure of 30 kgf/cm² and the volume of the cavity 32 reduced to a volume equivalent to 105% of the volume of the lens to be molded does not exceed said allowable value.

Similarly, it is said that the volumes of the cavities 32 and 33 are reduced to a volume equivalent to 110% of lenses to be molded when 95% of preparatorily measured resin is injected. The value "95%" is variable

according to the character of resin used and cavity shape.

The meaning of the value 95% will be described in more detail.

Due to the difference in the easiness of resin flow between the cavities 32 and 33, when the volumes of the cavities 32 and 33 are reduced to 110% of the volume of the lens to be molded, the cavity 33 would have an unfilled portion even if the cavity 32 is filled completely.

At this time, since the cavity 32 is completely filled, a large internal pressure is generated in the cavity 32, and its fluid resistance increases abruptly. While the fluid resistance of the cavity 33 having an unfilled portion has only a small fluid resistance. As a result, after the cavity 32 is completely filled, a greater part of injected resin flows into the cavity 33.

In addition, in the process of reducing the volumes of the cavities 32 and 33 to a volume equivalent to 105% of the lens to be molded including the molding shrinkage, resin backflowed from the cavity 32 and resin injected from the injection cylinder 28 flow into the cavity 33. As a result of the flow of resin into the cavity 33 and the volume reduction of the cavity 33 itself, unfilled portions in the cavity 33 are filled with resin.

However, when the unfilled portion remaining in the cavity 33 at the time when the volume of the cavity 33 is

reduced to a volume equivalent to 110% of the volume of the lens to be molded is larger than a certain value, unfilled portion remains in the cavity 33 when the volume of the cavity 33 is reduced to a volume equivalent to 105% of the volume of the lens to be molded.

Accordingly, when the maximum value of difference in easiness of resin flow between cavities 32 and 33 is considered, the value "95%" is determined so as to be in the range where the cavity 32 of easy resin flow is not overcharged to cause photoelastic distortion, and the cavity 33 of difficult resin flow does not have unfilled portion at the time when the volume of the cavities is reduced to the volume equivalent to 105% of that of the lens to be molded.

Now, when the position sensor 35 detects the injection of resin in the amount equivalent to 95% of preparatorily measured resin, the mold clamp cylinder 3 is controlled so that the volumes of the cavities 32 and 33 become a volume equivalent to 110% of the volume of the lens to be molded, and injection pressure of resin by the plunger 29 is lowered to 30 kgf/cm².

Accordingly, by this injection pressure 30 kgf/cm² resin injection operation further continues.

When the amount of injected resin exceeds 95% of preparatorily measured amount of resin and reaches 96% of the amount of preparatorily measured amount of resin, the

amount of oil to be supplied to the port 3a of the mold clamp cylinder 3 is further increased and the volumes of the cavities 32 and 33 are reduced to a volume equivalent to 105% of the volume of the lens to be molded.

As shown in Fig. 6, in the process in which the volumes of the cavities 32 and 33 are reduced to a volume equivalent to 105% of the volume of the lens to be molded, overcharged resin backflows from the cavity 32.

At the same time, the unfilled portion which remained when the volume is equivalent to 110% of the volume of the lens to be molded is filled with resin by the reduction of volume of the cavity 33 and with resin flowing by backflow pressure from the cavity 32 and by the injection pressure 30 kgf/cm² from the injection cylinder 28. The cavity 33 is also filled completely when the volume of the cavities 32 and 33 reaches 105% of the volume of the lens to be molded.

The injection pressure 30 kgf/cm² is the aforementioned retaining pressure, this retaining pressure does not obstruct backflow from overcharged cavity 32, and it is a pressure which can urge resin flow to the cavity 33 in which unfilled portion remains. It varies according to the shapes of the cavities 32 and 33 and the character of resin.

Now, at the time when the volume of the cavities

32 and 33 are reduced to a volume equivalent to 105% of the volume of the lens to be molded, both the cavities 32 and 33 are filled with resin completely, and it is possible that a greater pressure than the injection pressure 30 kgf/cm² is generated in the cavities 32 and 33 by filling of resin.

When this condition continued for a certain period of time (this time varies according to the fluidity of resin and the shape of the cavity but normally several seconds), internal pressures of the cavities 32 and 33 are balanced.

After the lapse of time required for the balancing of the internal pressures (or when the internal pressures of the cavities 32 and 33 are directly detected and both values detected are in balance with retaining pressure of 30 kgf/cm²), the sprue cutter 37 is caused to enter the sprue 30, and the resin injection operation is brought to end.

After the completion of the injection operation, the stamping process starts.

First, temperature in the cavities 32 and 33 is set to 130 °C throughout the process of the injection operation. At the temperature of 130 °C, resin is kept in a flow state.

Accordingly, though injected resin is cooled to 130 °C (temperature of molding apparatus) through the heat exchange with the molding apparatus, the resin in the cavities 32 and 33 maintains the flow condition and in the condition wherein the pressure is uniformly applied.

Therefore, when a pressure of 1013 kgf/cm^2 is applied to the resin in the cavities 32 and 33 by supplying oil to the port 3a of the mold clamp cylinder 3, this pressure is applied to the resin in the cavities 32 and 33 uniformly.

As mentioned already, thermoplastic resin is characteristic in that its dynamic modulus of elasticity increases and the resin is hardened as the resin is cooled, and the dynamic modulus of elasticity also increases and the resin is hardened when a pressure is applied.

The above-mentioned 1013 kgf/cm^2 is a pressure which can provide dynamic modulus of elasticity of the resin at normal temperature and normal pressure (naturally the dynamic modulus of elasticity exceeding that of glass transition point of acrylic resin) even when acrylic resin (material) is at a temperature as high as 130°C . The value of this pressure is established according to the kind and temperature of the resin.

When resin which is in a flow state under normal pressure is hardened by pressurizing to the pressure which gives dynamic modulus of elasticity equal to that of the resin at a normal temperature and under normal pressure, molded articles are excellent in compositional homogeneity because temperature difference does not occur when the resin in process of hardening passes through the glass transition



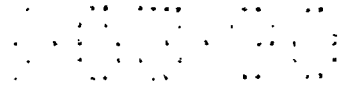
temperature.

The resin hardened by pressurization is cooled in the mold. By controlling the pressure of the mold clamp cylinder 3a as the resin is cooled, the resin is cooled to 95 ° C, which is a take-out temperature, while maintaining dynamic modulus of elasticity to that of the resin at normal temperature and under normal pressure.

Pressure control during this process is performed in the manner as shown below.

First, the pressure which gives dynamic modulus of elasticity equal to that of resin at a normal temperature and normal pressure is determined primarily by the temperature of the resin, and as the resin temperature decreases, the pressure which gives modulus of elasticity equal to that at a normal temperature and under normal pressure decreases. Therefore, in this embodiment, the pressure applied to the resin by the mold clamp cylinder 3a is reduced as the resin temperature is decreased to the pressure so that constant modulus of elasticity is obtained. In other words, in this embodiment, the pressure applied to the resin by the mold clamp cylinder 3a is decreased so as to cancel out the increase of dynamic modulus of elasticity of resin as the resin is cooled.

When the resin is cooled to 95 ° C (take-out temperature), the movable plate 6 is raised by supplying oil



to the port 3b of the mold clamp cylinder 3, and the lens is taken out by opening the junction of the lower mold plate 7 and the upper mold plate 10.

Minus lenses of average mass 18.430 g and diameter 70 mm were molded from acrylic resin by the method according to the present invention, and a comparison with similar lenses molded according to the conventional method was made. The result is as follows:

(1) Difference in charge quantity between cavities (left and right) when two cavities were provided in the mold apparatus.

Average difference was 4.9% in the case of conventional method while it was 0.5% in the case of the method according to the present invention.

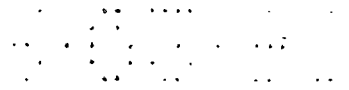
(2) Photoelastic distortion

Double refraction which is a result of photoelastic distortion was compared. The double refraction of lenses in accordance with the conventional method was 200 nm/cm, whereas that of lenses in accordance with the present invention was 20 nm/cm.

(3) Flow mark generation

Flow mark generation for entire moldings was 3.0% in the conventional method, while it was 1.0% in the molding method of the present invention.

As shown above, the molding method of the present



invention can sufficiently be employed in the molding of products whose precision and stable molding is considered difficult, such as nonspherical optical lens.

The essence of this invention is to prevent generation of weld mark due to flow resistance by injecting resin into the cavity which is expanded to a volume more than the volume obtained by adding a volume of an article to be molded and molding shrinkage resulted from the cooling of the resin and a volume sufficient for preventing divided flow of resin and is set to a temperature higher than required for maintaining a flow state of the resin.

to prevent imbalance of quantity of resin flowed into different cavities by reducing the volume of the cavities before the total quantity of preparatorily measured resin is injected,

to prevent generation of photoelastic distortion and a flow mark by preventing stop of resin flow in the cavities by controlling the injection pressure, injection quantity, and cavity volume in the reduction process of cavity volume; and to maintain compositional homogeneity of the molded article and prevent plastic deformation by reducing the temperature difference when the resin passes the glass transition point by hardening the resin in a flow state after completion of injection by only applying pressure which gives dynamic

modulus of elasticity equal to that of resin at a normal temperature and under normal pressure. It goes without saying that various numerical conditions must be determined properly depending on the kind of resin, shape of articles, and other factors.

Although an embodiment with regard to molding minus lenses from acrylic resin has been described, it is apparent that the method of present invention is applicable not only to plus lenses, but also to other molded articles than lenses.

According to the so far described present invention, the cavity volume is expanded to a volume capable of preventing divided flow of resin during the period from the start of injection at least to the time when the front end of resin flowing into the cavity passes the narrowest portion of the cavity thickness, and the cavity temperature is set at a level higher than the temperature at which the resin can maintain the flow state during the period from the start of injection to the completion of injection. Therefore, generation of weld mark can be prevented.

In addition, according to the present invention, the cavity volume reduction operation is started after the injection process has been advanced to the extent to prevent generation of weld marks and before the total quantity of the preparatorily measured resin is injected. And the

injection pressure and injection quantity are controlled so that unfilled portion does not remain in the cavity and excessively large overcharge does not occur while the cavity is reduced to a volume including the amount of shrinkage for the object volume, i.e., the volume of the product. In this manner, imbalance in the quantity of resin injected among a plurality of cavities can be prevented.

In addition, according to the present invention, since resin being injected is in a flow state and resin flow does not stop until resin of desired amount is injected, generation of photoelastic distortion and a flow mark caused by resin flow stop can be prevented.

In addition, according to the present invention, heterogeneity of internal plastics does not occur, because the resin is at a temperature capable of maintaining the flow state at the time of completion of the injection operation, and the resin is hardened by pressuring and therefore temperature difference does not occur when it passes the glass transition point in the process that the resin goes from the flow state to solid state and is hardened. In addition, by lowering the pressure so as to cancel out the increase of dynamic modulus of elasticity due to cooling in the later cooling process the dynamic modulus of elasticity of resin being cooled is maintained at the dynamic modulus of elasticity of the resin at normal

temperature and normal pressure, plastic deformation in the resin can be prevented. Accordingly, the generation of photoelastic distortion caused by plastic deformation and heterogeneity in the resin can be prevented.

C L A I M S

(1) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a cavity through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture a lens, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining a lens to be molded or more and injecting into a cavity having a volume being expanded preparatorily to a volume larger than the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with its temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

reducing the volume of said cavity to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of the thermoplastic resin after the injection proceeded to a sufficient quantity for the front end position of the thermoplastic resin injected to the cavity to pass the portion of an optical axis of the lens to be molded but

before the total quantity of the preparatorily measured thermoplastic resin is injected, reducing the injection pressure to a retaining pressure not obstructing backflow of said thermoplastic resin due to the reduction of the said cavity having the possibility of being overcharged and allowing the flow-in of said thermoplastic resin to a cavity having the possibility of leaving unfilled portions, and controlling the reduction speed of the volume of the cavity and the injection speed of the thermoplastic resin so that there is no unfilled portion in the cavity when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and the volume of the molding shrinkage due to the cooling of the thermoplastic resin:

sealing a sprue part when the behavior of the resin in the cavity is stabilized:

and

cooling the resin injected into the cavity until the resin is cooled to a take-out temperature while applying pressure and hardening the resin.

(2) An injection molding method with stamping compression according to Claim 1 wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part.

(3) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a cavity through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture a lens, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining a lens to be molded or more and injecting into a cavity having a volume being expanded preparatorily to a volume larger than the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with its temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

reducing the volume of said cavity to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of the thermoplastic resin after the injection proceeded to a sufficient quantity for the front end position of the thermoplastic resin injected to the cavity to pass the portion of an optical axis of the lens to be molded but before the total quantity of the preparatorily measured thermoplastic resin is injected, reducing the injection

pressure to a retaining pressure not obstructing backflow of said thermoplastic resin due to the reduction of the said cavity having the possibility of being overcharged and allowing the flow-in of said thermoplastic resin to a cavity having the possibility of leaving unfilled portions, and controlling the reduction speed of the volume of the cavity and the injection speed of the thermoplastic resin so that there is no unfilled portion in the cavity when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and the volume of the molding shrinkage due to the cooling of the thermoplastic resin:

sealing a sprue part when the behavior of the resin in the cavity is stabilized:

hardening the resin injected into the cavity by applying a pressure that gives dynamic modulus of elasticity of the resin at the normal temperature and normal pressure: and

cooling the resin hardened by pressure and continuing this cooling process until the resin is cooled to a take-out temperature while reducing the pressure so as to cancel out the rise of the dynamic modulus of elasticity due to cooling.

(4) An injection molding method with stamping compression according to Claim 3 wherein plasticized and

measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part.

(5) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a cavity through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture a lens, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining a lens to be molded or more and injecting into a cavity having a volume being expanded preparatorily to a volume larger than the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with its temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

proceeding to the cavity volume reduction stage after the injection operation progressed to a quantity sufficient for the front end position of the thermoplastic resin in the flow condition to pass the portion of the optical axis of the lens to be molded but before the total quantity of the preparatorily measured thermoplastic resin

is injected:

eventually reducing in the cavity volume reduction stage the injection pressure of the thermoplastic resin to a retaining pressure not obstruction backflow of said thermoplastic resin due to the reduction of the said cavity having the possibility of being overcharged to the cavity and allowing flow-in of said thermoplastic resin into the cavity having the possibility of leaving unfilled portions and reducing the volume of the cavity to a volume equal to the sum of the volume of the lens to be molded and the volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, further in this cavity volume reduction stage performing injection operation at an injection pressure greater than said retaining pressure up to a point when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion, regardless of variation of flow-in resistance to the cavity when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under the retaining pressure to the normal temperature and normal pressure, reducing the volume of the cavity to a volume not causing overcharge of the thermoplastic resin causing backflow beyond allowable range by the injection

operation at an injection pressure greater than the retaining pressure when the volume of said cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure by the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion regardless of variation of flow-in resistance to the said cavity is injected when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure.

lowering the injection pressure to said retaining pressure and reducing the volume of said cavity to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure after the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion regardless of the variation of flow-in resistance to said cavity is injected when the cavity volume is reduced to a volume equal to the sum of the volume of the lens to be molded and a

volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure:

sealing a sprue part when the behavior of the resin in the cavity is stabilized:

and

cooling the resin injected into the cavity until the resin is cooled to a take-out temperature while applying pressure and hardening the resin.

(6) An injection molding method with stamping compression according to Claim 5 wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part.

(7) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a cavity through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture a lens, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining a lens to be molded or more and injecting into a cavity having a volume being expanded preparatorily to a volume larger than the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic

resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with its temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

proceeding to the cavity volume reduction stage after the injection operation progressed to a quantity sufficient for the front end position of the thermoplastic resin in the flow condition to pass the portion of the optical axis of the lens to be molded but before the total quantity of the preparatorily measured thermoplastic resin is injected:

eventually reducing in the cavity volume reduction stage the injection pressure of the thermoplastic resin to a retaining pressure not obstruction backflow of said thermoplastic resin due to the reduction of the said cavity having the possibility of being overcharged to the cavity and allowing flow-in of said thermoplastic resin into the cavity having the possibility of leaving unfilled portions and reducing the volume of the cavity to a volume equal to the sum of the volume of the lens to be molded and the volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, further in this cavity volume reduction stage performing injection operation at an injection

pressure greater than said retaining pressure up to a point when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion regardless of variation of flow-in resistance to the cavity when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under the retaining pressure to the normal temperature and normal pressure, reducing the volume of the cavity to a volume not causing overcharge of the thermoplastic resin causing backflow beyond allowable range by the injection operation at an injection pressure greater than the retaining pressure when the volume of said cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure by the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion regardless of variation of flow-in resistance to the said cavity is injected when the volume of the cavity is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and

normal pressure, lowering the injection pressure to said retaining pressure and reducing the volume of said cavity to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure after the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the cavity free of unfilled portion regardless of the variation of flow-in resistance to said cavity is injected when the cavity volume is reduced to a volume equal to the sum of the volume of the lens to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure:

sealing a sprue part when the behavior of the resin in the cavity is stabilized:

hardening the resin injected into the cavity by applying a pressure that gives dynamic modulus of elasticity of the resin at the normal temperature and normal pressure: and

cooling the resin hardened by pressure and continuing this cooling process until the resin is cooled to a take-out temperature while reducing the pressure so as to cancel out the rise of the dynamic modulus of elasticity due to cooling.

(8) An injection molding method with stamping compression according to Claim 7 wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part.

(9) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture molded articles, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining molded articles to be molded or more and injecting into the plurality of cavities having a volume being expanded preparatorily to a volume larger than the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with their temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

reducing the volume of said plurality of cavities to a volume equal to the sum of the volume of the molded

articles to be molded and a volume of molding shrinkage due to the cooling of the thermoplastic resin before the total quantity of the preparatorily measured thermoplastic resin is injected, reducing the injection pressure to a retaining pressure not obstructing backflow of said thermoplastic resin due to the reduction of the said individual cavities having the possibility of being overcharged and allowing the flow-in of said thermoplastic resin to the cavities having the possibility of leaving unfilled portions, and controlling the reduction speed of the volume of said plurality of cavities and the injection speed of the thermoplastic resin so that there is no unfilled portion in the individual cavities when the volume of the plurality of cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and the volume of the molding shrinkage due to the cooling of the thermoplastic resin:

sealing a sprue part when the behavior of the resin in the cavities are stabilized:

and

cooling the resin injected into the plurality of cavities until the resin is cooled to a take-out temperature while applying pressure and hardening the resin.

(10) An injection molding method with stamping compression wherein plasticized and measured thermoplastic

resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture molded articles, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining a molded articles to be molded or more and injecting into the plurality of cavities having a volume being expanded preparatorily to a volume larger than the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with their temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

reducing the volume of said plurality of cavities to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of the thermoplastic resin before the total quantity of the preparatorily measured thermoplastic resin is injected, reducing the injection pressure to a retaining pressure not obstructing backflow of said thermoplastic resin due to the reduction of the said individual cavities having the possibility of being overcharged and allowing the

flow-in of said thermoplastic resin to the cavities having the possibility of leaving unfilled portions, and controlling the reduction speed of the volume of said plurality of cavities and the injection speed of the thermoplastic resin so that there is no unfilled portion in the individual cavities when the volume of the plurality of cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and the volume of the molding shrinkage due to the cooling of the thermoplastic resin:

sealing a sprue part when the behavior of the resin in the cavities are stabilized:

hardening the resin injected into the cavities by applying a pressure that gives dynamic modulus of elasticity of the resin at the normal temperature and normal pressure: and

cooling the resin hardened by pressure and continuing this cooling process until the resin is cooled to a take-out temperature while reducing the pressure so as to cancel out the rise of the dynamic modulus of elasticity due to cooling.

(11) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and

gate part, and cooled with a mold clamping force applied to manufacture molded articles, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining molded articles to be molded or more and injecting into the plurality of cavities having a volume being expanded preparatorily to a volume larger than the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with their temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

proceeding to the cavity volume reduction stage before the total quantity of the preparatorily measured thermoplastic resin is injected:

eventually reducing in the cavity volume reduction stage the injection pressure of the thermoplastic resin to a retaining pressure not obstruction backflow of said thermoplastic resin due to the reduction of the said individual cavities having the possibility of being overcharged to the cavities and allowing flow-in of said thermoplastic resin into the cavities having the possibility of leaving unfilled portions and reducing the volume of said plurality of

cavities to a volume equal to the sum of the volume of the molded articles to be molded and the volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, further in this cavity volume reduction stage performing injection operation at an injection pressure greater than said retaining pressure up to a point when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the individual cavitiés free of unfilled portion regardless of variation of flow-in resistance to the cavities when the volume of the cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under the retaining pressure to the normal temperature and normal pressure, reducing the volume of the plurality of cavities to a volume not causing overcharge of the thermoplastic resin causing backflow beyond allowable range by the injection operation at an injection pressure greater than the retaining pressure when the volume of said cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure by the time when the thermoplastic resin of

a quantity necessary as well as sufficient for maintaining the individual cavities free of unfilled portion regardless of variation of flow-in resistance to the said cavities is injected when the volume of the cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, lowering the injection pressure to said retaining pressure and reducing the volume of said plurality of cavities to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure after the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the individual cavities free of unfilled portion regardless of the variation of flow-in resistance to said cavities is injected when the volume of said cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure :

sealing a sprue part when the behavior of the resin in the cavities are stabilized:

and

cooling the resin injected into the plurality of cavities until the resin is cooled to a take-out temperature while applying pressure and hardening the resin.

(12) An injection molding method with stamping compression wherein plasticized and measured thermoplastic resin is injected to a plurality of cavities formed in a single mold apparatus through a sprue part, runner part, and gate part, and cooled with a mold clamping force applied to manufacture molded articles, comprising:

preparatorily measuring a quantity of molten thermoplastic resin required for obtaining molded articles to be molded or more and injecting into the plurality of cavities having a volume being expanded preparatorily to a volume larger than the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin and being expanded preparatorily to a sufficient volume or more for preventing divided flow of flowing resin with their temperature being set at a level equal to or higher than a temperature capable of maintaining injected resin in a flowing state:

proceeding to the cavity volume reduction stage before the total quantity of the preparatorily measured thermoplastic resin is injected:

eventually reducing in the cavity volume reduction stage the injection pressure of the thermoplastic resin to a retaining pressure not obstruction backflow of said thermoplastic resin due to the reduction of the said individual cavities having the possibility of being overcharged to the cavities and allowing flow-in of said thermoplastic resin into the cavities having the possibility of leaving unfilled portions and reducing the volume of said plurality of cavities to a volume equal to the sum of the volume of the molded articles to be molded and the volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, further in this cavity volume reduction stage performing injection operation at an injection pressure greater than said retaining pressure up to a point when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the individual cavities free of unfilled portion regardless of variation of flow-in resistance to the cavities when the volume of the cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under the retaining pressure to the normal temperature and normal pressure, reducing the volume of the plurality of cavities to a volume not causing overcharge of the

thermoplastic resin causing backflow beyond allowable range by the injection operation at an injection pressure greater than the retaining pressure when the volume of said cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure by the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the individual cavities free of unfilled portion regardless of variation of flow-in resistance to the said cavities is injected when the volume of the cavities are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure, lowering the injection pressure to said retaining pressure and reducing the volume of said plurality of cavities to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure after the time when the thermoplastic resin of a quantity necessary as well as sufficient for maintaining the individual cavities free of unfilled portion regardless of

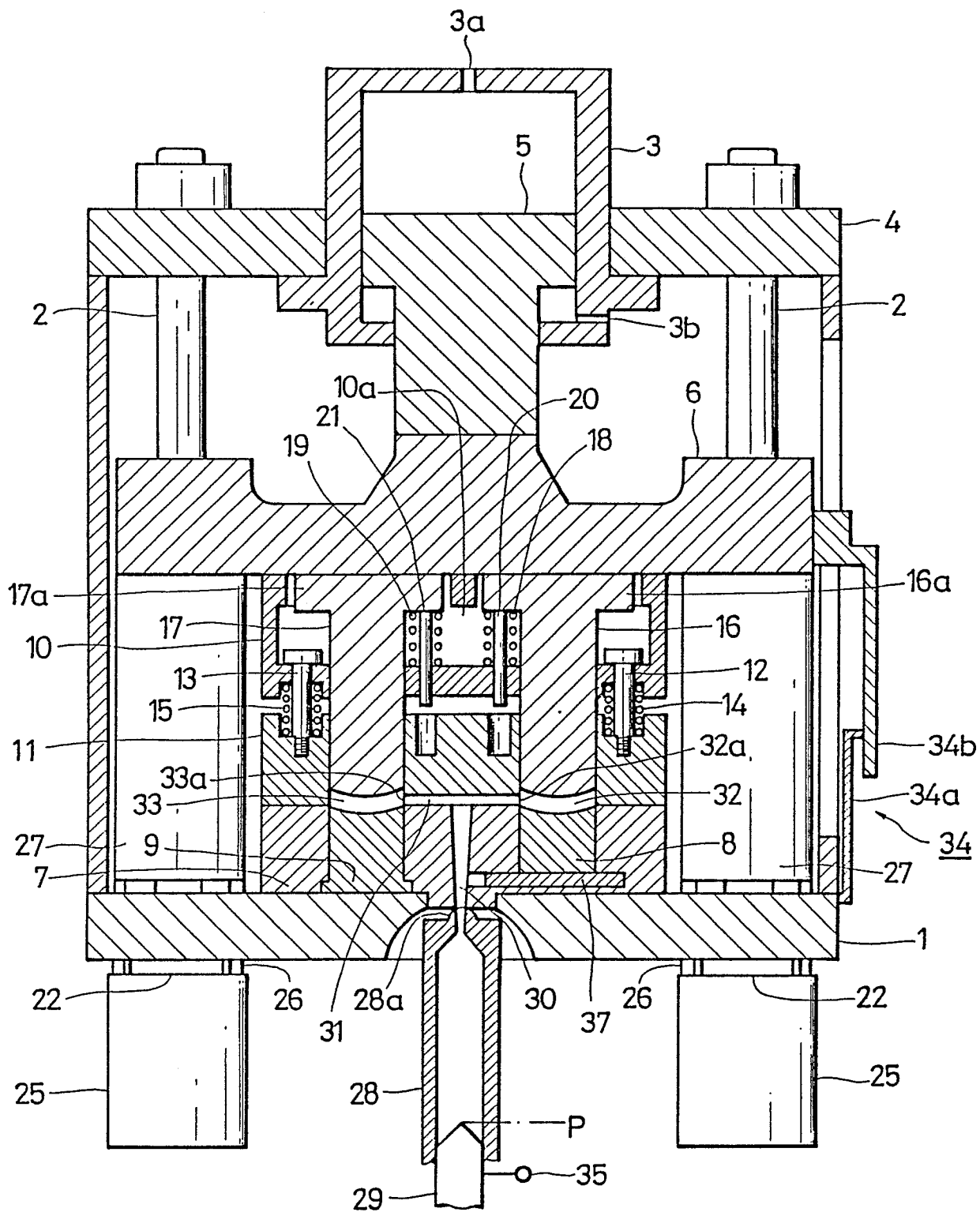
the variation of flow-in resistance to said cavities is injected when the volume of said cavity are reduced to a volume equal to the sum of the volume of the molded articles to be molded and a volume of molding shrinkage due to the cooling of said thermoplastic resin under said retaining pressure to the normal temperature and normal pressure :

sealing a sprue part when the behavior of the resin in the cavities are stabilized:

hardening the resin injected into the cavities by applying a pressure that gives dynamic modulus of elasticity of the resin at the normal temperature and normal pressure: and

cooling the resin hardened by pressure and continuing this cooling process until the resin is cooled to a take-out temperature while reducing the pressure so as to cancel out the rise of the dynamic modulus of elasticity due to cooling.

3a



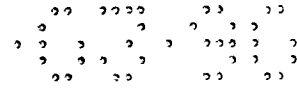
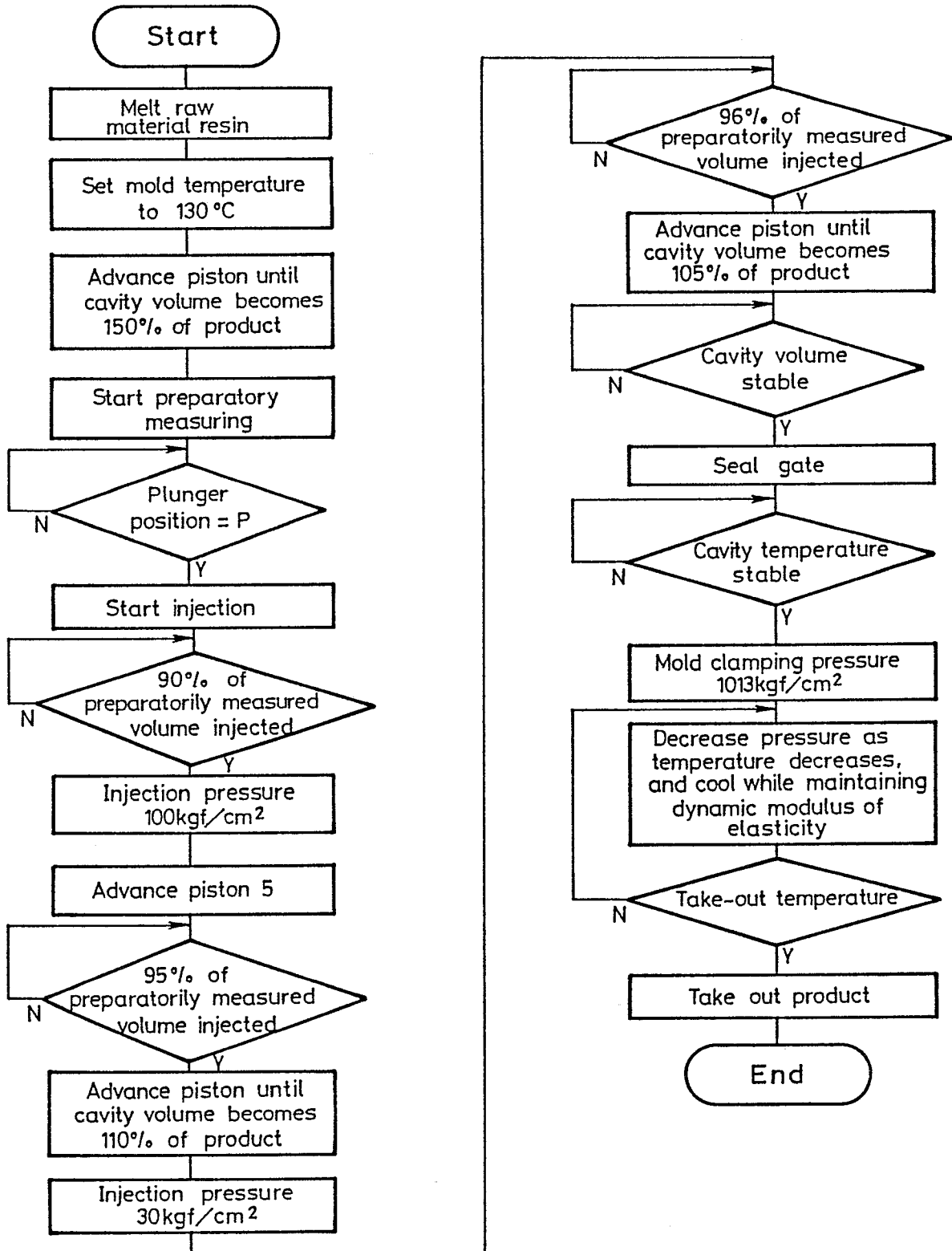


FIG.3



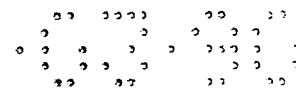


FIG.4

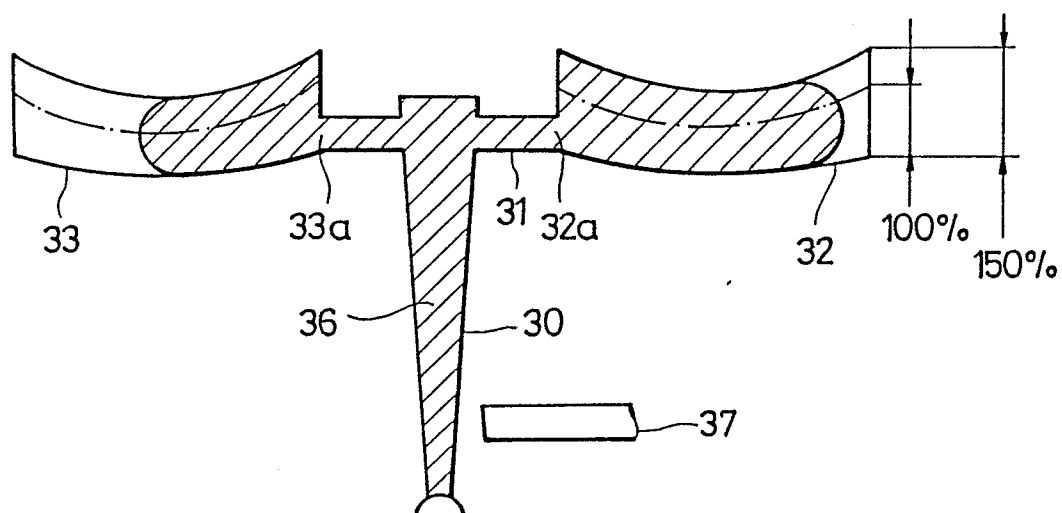
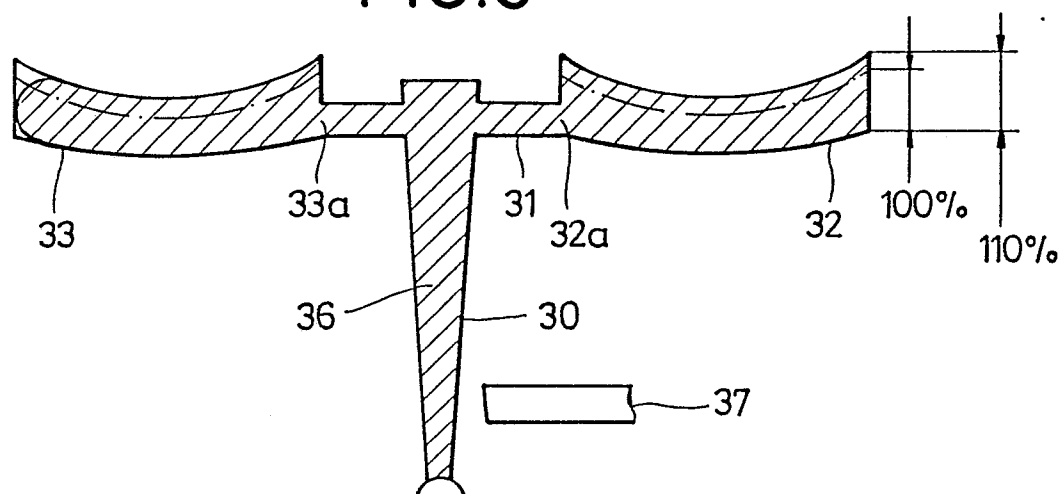


FIG.5



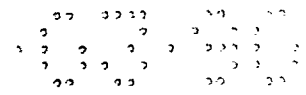


FIG.6

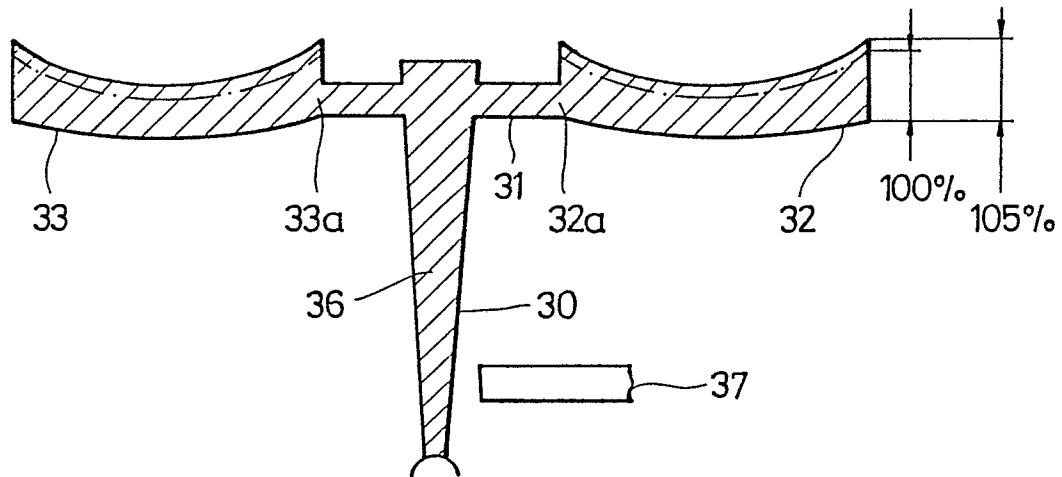
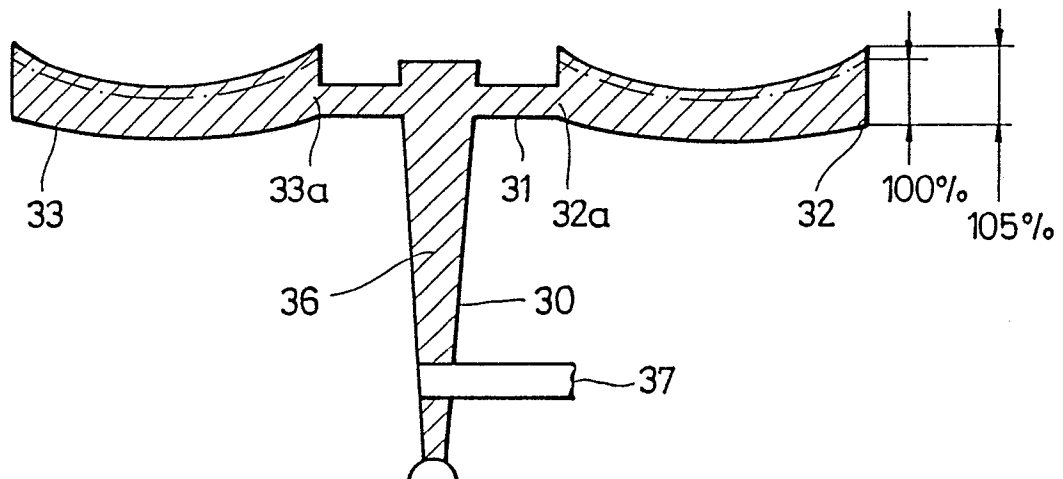


FIG.7



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP89/00710

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC Int. Cl⁴ B29C45/56, 45/70, 45/76											
II. FIELDS SEARCHED Minimum Documentation Searched ⁷ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 20%; font-size: small;">Classification System</th> <th style="font-size: small;">Classification Symbols</th> </tr> <tr> <td style="text-align: center; padding: 10px;">IPC</td> <td style="padding: 10px;">B29C45/56, 45/76, 45/77, 45/80, 45/70</td> </tr> </table>			Classification System	Classification Symbols	IPC	B29C45/56, 45/76, 45/77, 45/80, 45/70					
Classification System	Classification Symbols										
IPC	B29C45/56, 45/76, 45/77, 45/80, 45/70										
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸ <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;">Jitsuyo Shinan Koho</td> <td style="width: 50%; padding: 5px;">1938 - 1989</td> </tr> <tr> <td style="padding: 5px;">Kokai Jitsuyo Shinan Koho</td> <td style="padding: 5px;">1971 - 1989</td> </tr> </table>			Jitsuyo Shinan Koho	1938 - 1989	Kokai Jitsuyo Shinan Koho	1971 - 1989					
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; font-size: small;">Category ¹⁰</th> <th style="font-size: small;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%; font-size: small;">Relevant to Claim No. ¹³</th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">JP, A, 63-139720 (Aida Engineering Ltd.) 11 June 1988 (11. 06. 88) Claim (Family : none)</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1 - 12</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;">JP, A, 55-39355 (Keiden Kogyosho Kabushiki Kaisha) 19 March 1980 (19. 03. 80) Claim (Family : none)</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1 - 12</td> </tr> </table>			Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	A	JP, A, 63-139720 (Aida Engineering Ltd.) 11 June 1988 (11. 06. 88) Claim (Family : none)	1 - 12	A	JP, A, 55-39355 (Keiden Kogyosho Kabushiki Kaisha) 19 March 1980 (19. 03. 80) Claim (Family : none)	1 - 12
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[*] Special categories of cited documents: ¹⁰ "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "Z" document member of the same patent family											
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> Date of the Actual Completion of the International Search October 2, 1989 (02. 10. 89) </td> <td style="width: 50%; padding: 5px;"> Date of Mailing of this International Search Report October 16, 1989 (16. 10. 89) </td> </tr> <tr> <td style="width: 50%; padding: 5px;"> International Searching Authority Japanese Patent Office </td> <td style="width: 50%; padding: 5px;"> Signature of Authorized Officer </td> </tr> </table>			Date of the Actual Completion of the International Search October 2, 1989 (02. 10. 89)	Date of Mailing of this International Search Report October 16, 1989 (16. 10. 89)	International Searching Authority Japanese Patent Office	Signature of Authorized Officer					
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